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(54) Abstract Title
A control system for driving and navigating an autonomous robot cleaner.

(57) The robot cleaner 10 is in wirelessly communication with an external device 40. The robot cleaner comprises a driving unit 15 that drives a plurality of wheels (15a-d, fig. 2) mounted on a body of the robot, a dust collecting portion 11, and a plurality of proximity switches/sensors $12c_1$-$12c_5$ for use in detecting either a metal member or a metal line disposed in a floor surface within a work area. A controller 18 is used to receive outputted signals from the proximity switches in order to determine the robots position and calculate a travelling course. Preferably the proximity switches have an oscillator that generates a wave signal through a wave detection coil. Furthermore a method of controlling the robot cleaner is disclosed. The method comprising a step of generating and storing a map representing the pattern of the metal lines/members while the robot moves in the working area. The controller determining the position of the robot by comparing the signals from the proximity switches and the pattern map. Other sensors may be fitted to the robot such as a camera (13, fig. 1) to help prevent it from colliding into any obstacles. The robot could also be externally charged by an independent charging unit 30.

FIG.3

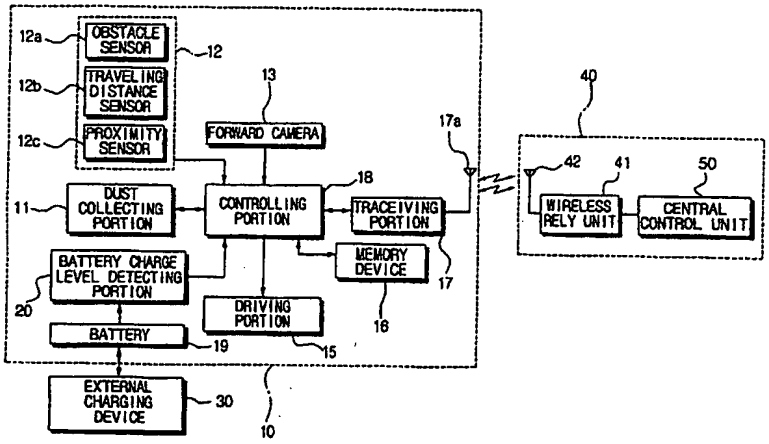

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FIG. 1

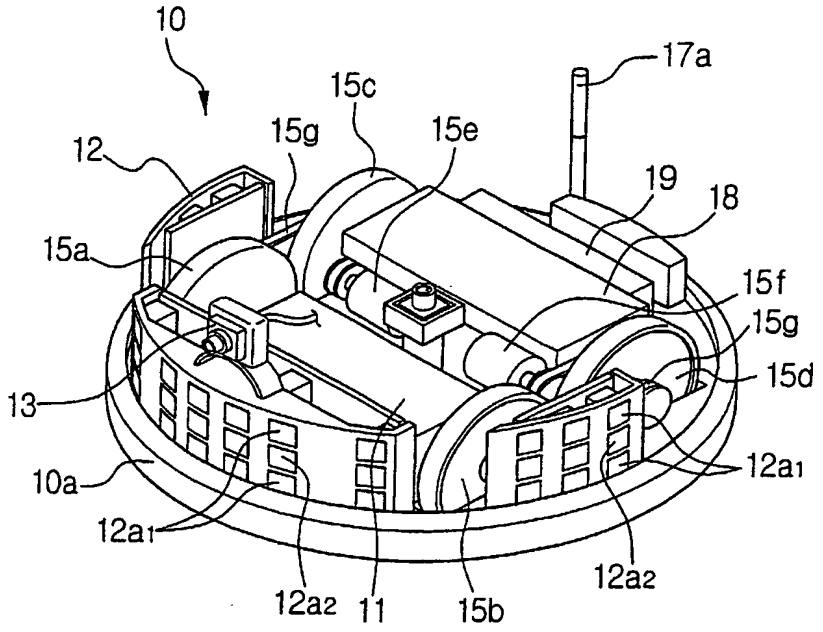

10
17a
15c
15g
15e
12
19
18
15a
15f
15g
15d
13
12a1
10a
12a1
12a2
11
15b
12a2

FIG. 2

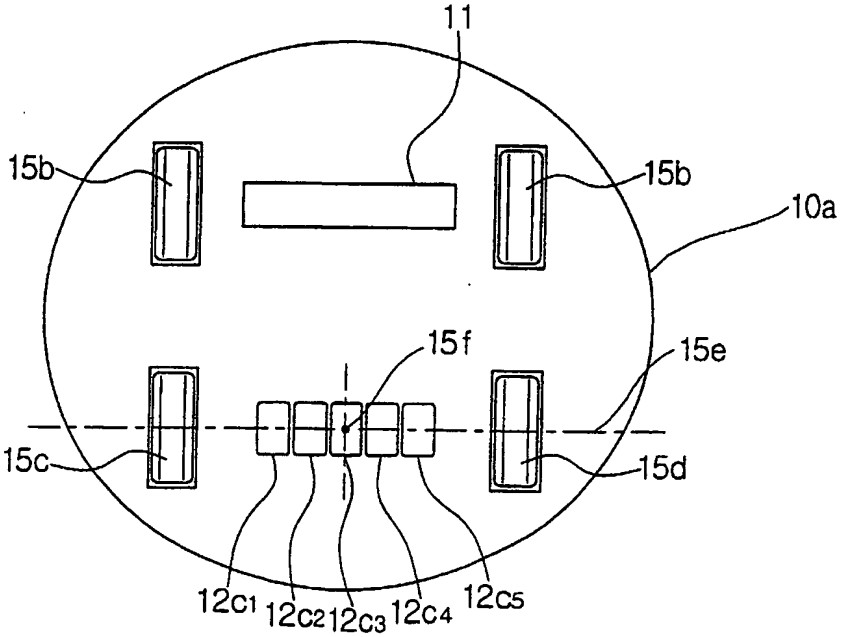

11
15b
15b
10a
15f
15e
15c
15d
12c1
12c2
12c3
12c4
12c5

FIG.3

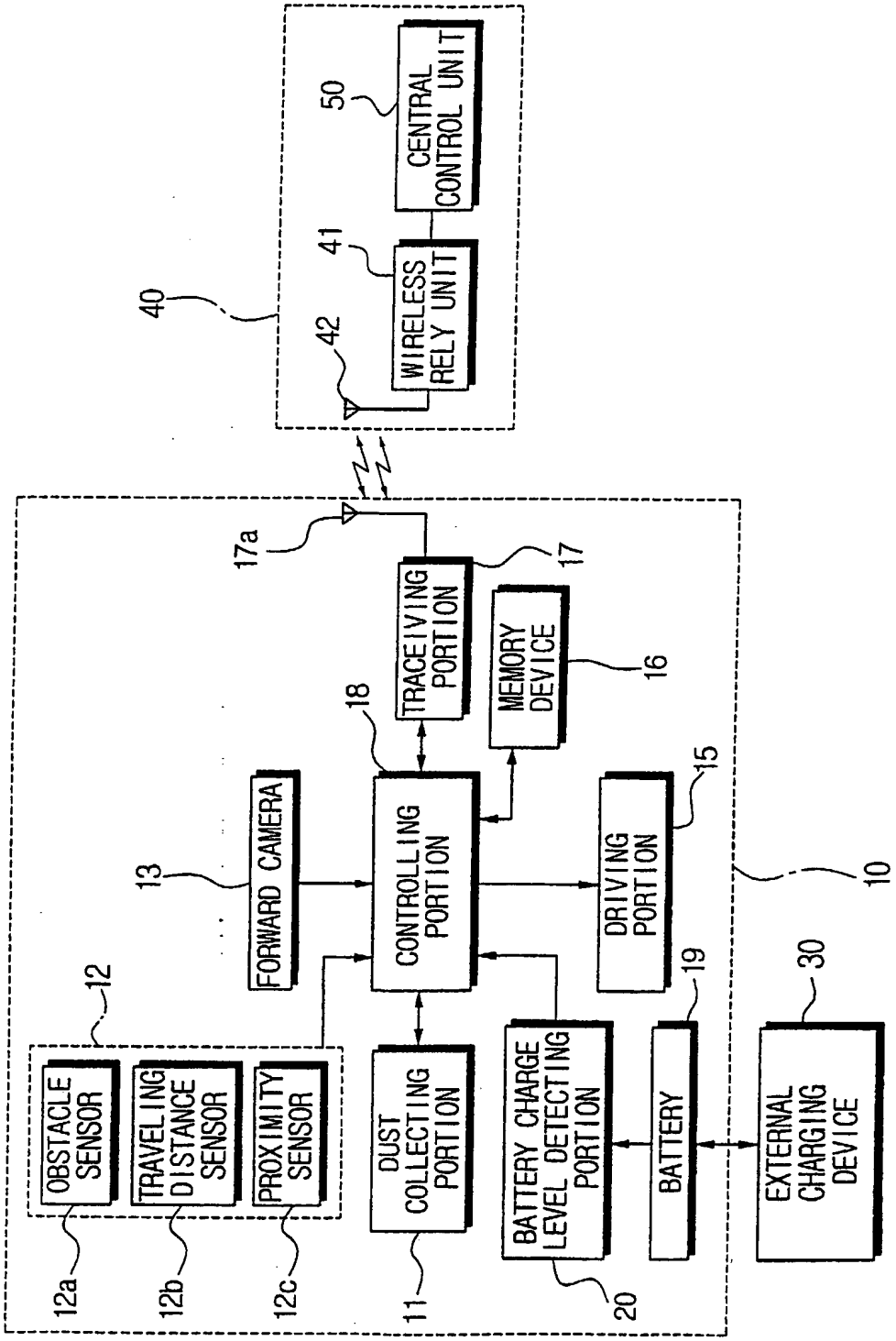

40
50
CENTRAL CONTROL UNIT
41
WIRELESS RELY UNIT
42
17a
17
TRACEIVING PORTION
MEMORY DEVICE
16
18
13
FORWARD CAMERA
CONTROLLING PORTION
15
DRIVING PORTION
10
12
OBSTACLE SENSOR
TRAVELING DISTANCE SENSOR
PROXIMITY SENSOR
DUST COLLECTING PORTION
BATTERY CHARGE LEVEL DETECTING PORTION
19
BATTERY
30
EXTERNAL CHARGING DEVICE
12a
12b
12c
11
20

FIG.4

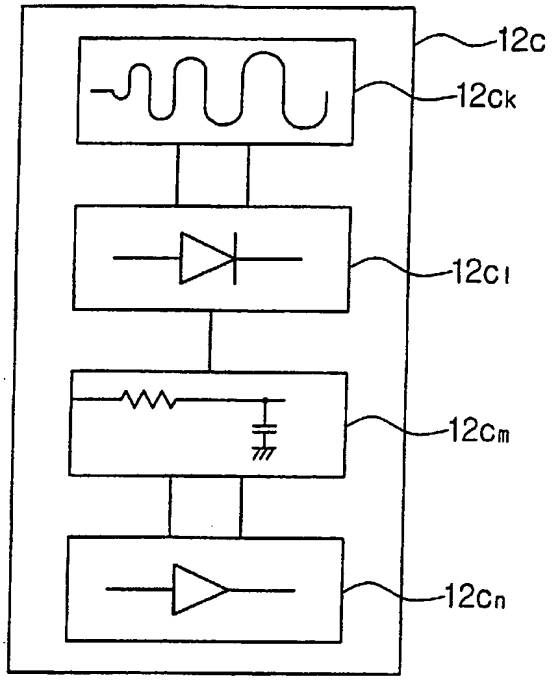


FIG.5

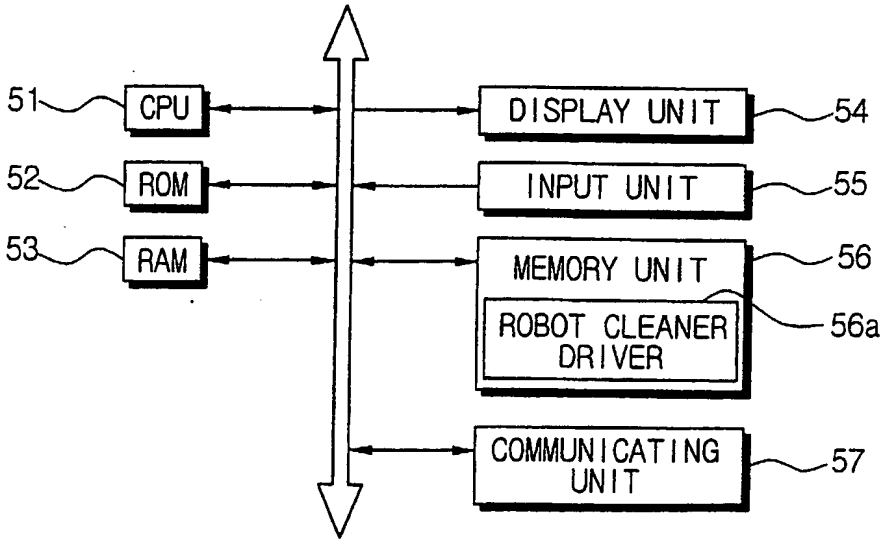


FIG. 5

FIG.6A

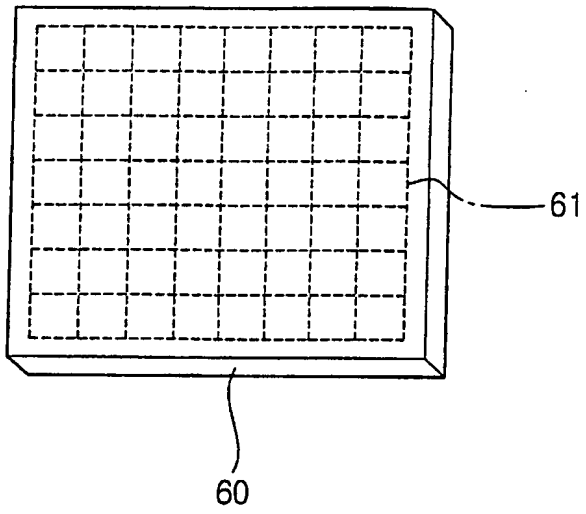


FIG.6B

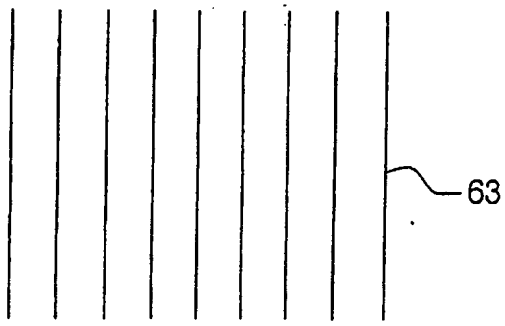


FIG.6C

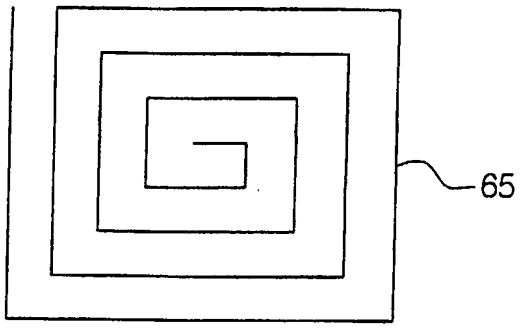


FIG.6D

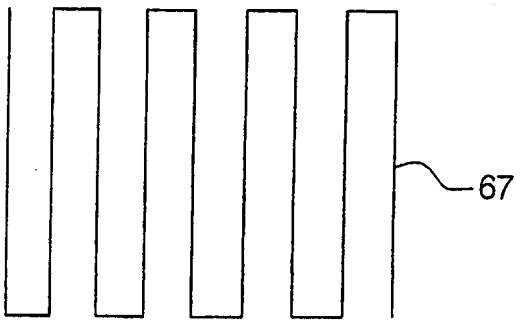


FIG.7

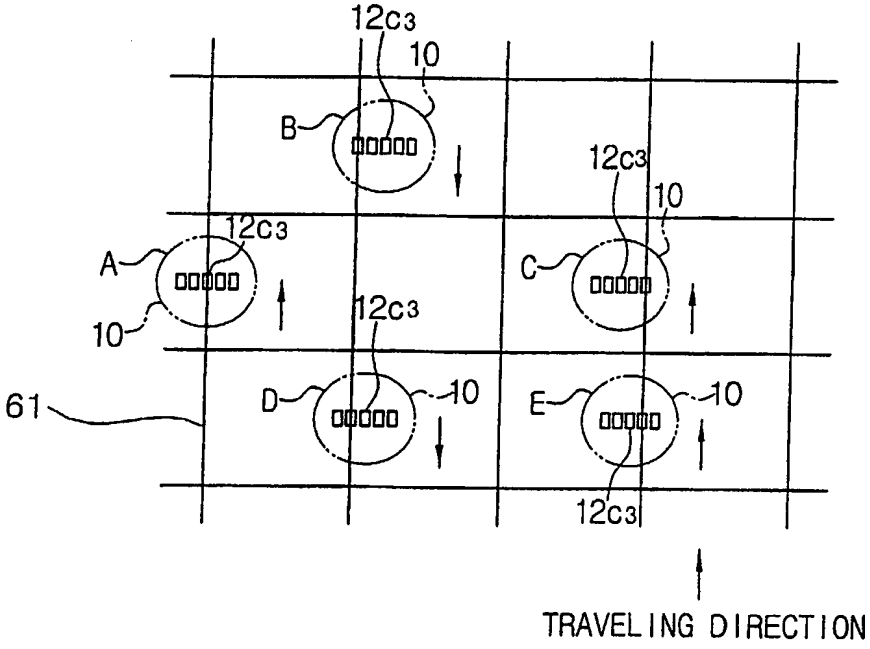
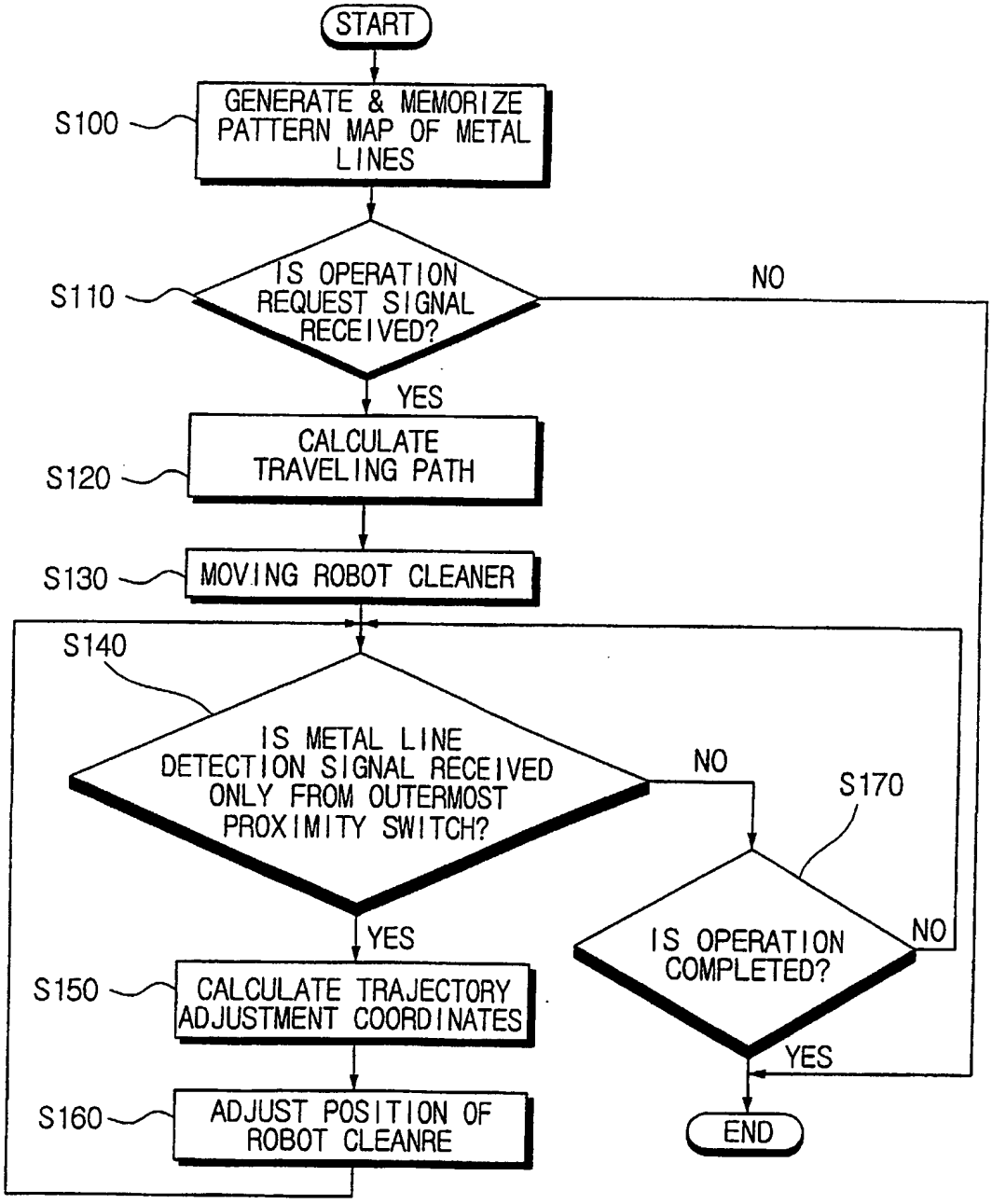

12c3
10
B
12c3
10
A
12c3
C
10
12c3
61
D
10
E
10
12c3
TRAVELING DIRECTION

FIG.8


START
S100
GENERATE & MEMORIZE PATTERN MAP OF METAL LINES
S110
IS OPERATION REQUEST SIGNAL RECEIVED?
NO
YES
S120
CALCULATE TRAVELING PATH
S130
MOVING ROBOT CLEANER
S140
IS METAL LINE DETECTION SIGNAL RECEIVED ONLY FROM OUTERMOST PROXIMITY SWITCH?
NO
S170
IS OPERATION COMPLETED?
NO
YES
YES
S150
CALCULATE TRAJECTORY ADJUSTMENT COORDINATES
S160
ADJUST POSITION OF ROBOT CLEANRE
END

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A ROBOT CLEANER, A ROBOT CLEANER SYSTEM AND A METHOD OF CONTROLLING A ROBOT CLEANER

The present invention relates to a robot cleaner, a robot cleaner system, and a method of controlling a robot cleaner.

A known robot cleaner operates by automatically travelling over an underlying cleaning surface within a predetermined cleaning area, whilst drawing in particles such as dirt or dust from the cleaning surface. During this operation, the robot cleaner determines the distance between itself and obstacles such as furniture and walls. The robot cleaner is controlled so as not to collide with these obstacles.

To ensure that the robot cleaner has cleaned the whole area, it is configured to recognise its own position with respect to the overall area.

Although there has been research as to the particular way in which a robot cleaner can be configured to recognise its own position, for example by storing images of its position using a camera, due to the heavy processing requirements of image recognition algorithms which are used, and the likelihood of position recognition error occurring due to changes in the robot's surroundings, the accuracy of such image recognition algorithms is limited, as is commercial use of such systems.

It is desirable to reduce the above-mentioned problems of the related art. It would be desirable to provide a robot cleaner, a system thereof, and a method for controlling the same, capable not only of accurately recognising the robot cleaner's position but also of reducing the processing burden of having to process algorithms for position recognition.

According to one aspect of the invention, there is provided a robot cleaner for performing a cleaning operation while wirelessly communicating with an external device, comprising: a driving portion that drives a plurality of wheels mounted on a

body of the robot cleaner; a dust collecting portion mounted on the body and arranged to collect dust from a floor surface within a work area; a plurality of proximity switches arranged on a lower surface of the body facing the floor surface, the switches being spaced apart from each other by a predetermined distance and arranged to detect the existence of a metal member in the region of the floor surface; and a controlling portion arranged to calculate a measure of the travelling distance and travelling course of the cleaner using a signal outputted from the proximity switches and to control the driving portion to perform an assigned operation using the calculated course.

According to a further aspect of the invention, there is provided a robot cleaner for performing a cleaning operation while wirelessly communicating with an external device, comprising: a driving portion that drives a plurality of wheels mounted on a body of the robot cleaner; a dust collecting portion mounted on the body and arranged to collect dust from a floor surface within a work area; a plurality of proximity switches arranged on a lower surface of the body facing the floor surface, the switches being spaced apart from each other by a predetermined distance and arranged to detect the existence of a metal member in the region of the floor surface; and a controlling portion arranged to calculate a measure of the travelling distance and travelling course of the cleaner using a signal outputted from the proximity switches and to control the driving portion to perform an assigned operation using the calculated course.

The proximity switches may include an oscillator that oscillates through a detection coil, a wave detector that detects the amplitude of oscillation from the detection coil, and an integrator that integrates and outputs a signal outputted through the wave detector.

The proximity switches may be disposed in a row along an axis extending between laterally opposed wheels of the cleaner.

An odd number of proximity switches may be provided and arranged such that one proximity switch is placed centrally, between the laterally opposed wheels, and the

remainder of the proximity switches are placed, in equal number, either side of the central proximity switch in a symmetrical manner.

According to a further aspect of the invention, there is provided a robot cleaner system comprising a robot cleaner that performs a cleaning operation while communicating wirelessly with an external device, the robot cleaner having a plurality of proximity switches arranged in a row on a lower portion of a body, and a guiding plate disposed substantially on or in a floor of a work area, the guiding plate including metal lines formed in a predetermined pattern, the metal lines being detectable by the proximity switches.

The metal lines may be formed on a lower surface of the guiding plate.

According to a further aspect of the invention, there is provided a method of controlling a robot cleaner, the robot cleaner being arranged to recognise a travelling location by using a detection signal from a plurality of proximity switches, and arranged on a lower surface of a body of the cleaner at a predetermined distance from one another, and being configured to detect metal lines formed in a predetermined pattern on a floor surface of a work area, the method comprising the steps of: generating and storing a map representing the pattern of metal lines while moving the robot cleaner within the work area; in response to receiving an operation request signal, determining the location of the robot cleaner by comparing the pattern map with a detection signal generated by the proximity switches; calculating a travelling path from the determined location to a targeting location; and moving the robot cleaner along the calculated travelling path.

At least three proximity switches may be provided and arranged in a row along an axis extending between two laterally opposed wheels of the robot cleaner, the controlling method further comprising the steps whereby: when a detection signal is received from an outermost proximity switch during the travelling process, the travelling process is temporarily stopped and course adjustment co-ordinates are calculated, which co-ordinates include change of direction and forwards-moving direction information required so that the central proximity switch is location over the metal line; moving the

robot cleaner in accordance with the course adjustment co-ordinates; and when the metal line is detected by the proximity switch in the middle, continuing the operation requested in the operation request signal.

According to a further aspect of the invention, there is provided a robot cleaner for performing a cleaning operation on an underlying cleaning surface while includes one or more metallic members arranged in a predetermined pattern, the robot cleaner comprising: a body having a plurality of proximity sensors arranged on a lower surface thereof, each proximity sensor being arranged to output a detection signal in response to being within a predetermined range of a metallic member of the cleaning surface; and control means arranged to receive a detection signal from one or more of the proximity sensors thereby to determine the position of the robot cleaner on the underlying cleaning surface.

According to a further aspect of the invention, there is provided a robot cleaner system, comprising: a robot cleaner; a surface comprising one or more metallic members arranged in a predetermined pattern thereover, wherein the robot cleaner is arranged to perform a cleaning operation over the surface and comprises (i) a body having a plurality of proximity sensors arranged on a lower surface thereof, each proximity sensor being arranged to output a detection signal in response to being within a predetermined rage of the or one metallic member of the surface, and (ii) control means arranged to receive a detection signal from one or more of the proximity sensors thereby to determine the position of the robot cleaner on the underlying cleaning surface.

According to a further aspect of the invention, there is provided a method of controlling a robot cleaner as described previously, the method comprising: driving the robot cleaner over an underlying cleaning surface including one or more metallic members arranged in a predetermined pattern; operating the robot cleaner such that it generates and stores a map representing the pattern of the or each sensed metallic member; in response to receiving a command signal from an external device, determining the current position of the robot cleaner using one or more of the sensors; calculating a path

from the current position to a target position indicated in the command signal; and moving the robot cleaner along the calculated path.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of part of a robot cleaner, the robot cleaner being shown with its cover removed;

Figure 2 is a bottom plan-view of the robot cleaner of Figure 1;

Figure 3 is a block diagram representing functional elements of a robot cleaner system employing the robot cleaner partly shown in Figure 1;

Figure 4 is a block diagram of a proximity sensor shown in Figure 1;

Figure 5 is a block diagram showing a central control unit, as represented in Figure 3;

Figures 6A to 6D show examples of metal lines which may be disposed in a cleaning surface over which the robot cleaner may move;

Figure 7 is a plan-view of a cleaning surface, the view being useful for explaining a course adjustment process employed by the robot cleaner system; and

Figure 8 is a flowchart illustrating a course adjustment process during a cleaning operation of the robot cleaner of Figure 1.

Referring to Figures 1 to 3, a robot cleaner 10 includes a body 10a, a dust collecting portion 11, a sensor portion 12, a front camera 13, a driving portion 15, a memory device 16, a transceiving portion 17, a controlling portion 18, and a battery 19.

The dust collecting portion 11 is mounted on the body 10a, and is arranged to collect dust from an underlying cleaning surface as air is drawn in. The dust collecting portion 11 can be constructed in accordance with known methods. For example, the dust collecting portion 11 may include a suction motor (not shown) and a dust collecting chamber that collects dust drawn in through a suction port or suction pipe, when the suction motor is driven. The suction port or suction pipe is usually arranged so that it is adjacent the underlying cleaning surface.

The sensor portion 12 includes a plurality of obstacle sensors 12a arranged on the outer surface of the body 10a, spaced apart from each other by a predetermined distance. The obstacle sensors 12a are arranged to emit signals and to receive reflected versions of the signals. A distance sensor 12b is provided for sensing the travelling distance of the robot cleaner 10. Proximity switches 12c are also provided.

The obstacle sensors 12a include light emitting elements 12a1, and light receiving elements 12a2 that receive the reflections of the light emitted from the light emitting elements, the emitting and receiving elements being arranged around the outer circumference of the obstacle sensor 12a and being spaced apart by a predetermined distance. As shown in Figure 1, the light emitting and receiving elements 12a1, 12a2 are arranged in vertical rows.

Alternatively, the obstacle sensors 12a can be ultrasonic sensors that emit ultrasonic waves and receive reflected ultrasonic waves.

As well as sensing obstacles, the obstacle sensors 12a can also be used to measure the distance between the robot cleaner 10 and an obstacle or wall.

The distance sensors 12b may be in the form of one or more 'RPM' sensors that sense the number of revolutions per minute (hence RPM) of first to fourth wheels 15a - 15d. For example, the RPM sensor may be an encoder that detects the RPM of first and second motors 15e, 15f which drive the wheels 15a - 15d.

As shown in Figure 2, the proximity switches 12c are arranged on the lower surface of the body 10a, so that in operation they face an underlying cleaning surface.

Preferably, the proximity switches 12c are arranged so that they are spaced apart by a predetermined distance and are arranged in a generally symmetrical pattern, in this case along an axis 15e intersecting the central axle points of the wheels 15c and 15d. An odd number of proximity switches 12c are provided so that one proximity switch 12c3 is central, i.e. at the mid-point 15f of the imaginary line 15e, with the remainder of proximity switches 12c being disposed either side of the central proximity switch 12c3 in equal numbers. In Figure 2, there are five proximity switches 12c.

Given the above-described arrangement, the course of the robot cleaner 10 is easily adjusted in accordance with signals derived from the proximity switches 12c, with units of adjustment being defined as units of orthogonal rotation and straight movement.

Preferably, the proximity switches 12c operate in a well-known manner in which they detect a metal material located within a predetermined range of the switch. Here, the metal material is located in the underlying cleaning surface.

The proximity switches 12c may be oscillation-type switches that detect the existence of metal material by generating an oscillating signal of predetermined frequency, and then detecting the amplitude variation of the returning oscillating signal which will vary due to its interaction with a metal material which is close to the switches. The metal material affects the magnetic field generated by the oscillating signal. The proximity switches 12c may be capacitative type switches that detect the existence of nearby objects by detecting a capacitance variation which is dependent on the distance between a detecting electrode of the switch and the nearby object.

In this embodiment, the proximity switches 12c are of the oscillation-type.

As shown in Figure 4, the general structure of each oscillation-type switch 12c includes an oscillator $12c_k$, a wave detector $12c_l$, and an integrator $12c_m$. Depending on the signal sensing ability, an amplifier $12c_n$ may also be provided.

The oscillator $12c_k$ generates a high frequency oscillating signal through a detection coil arranged adjacent the underlying surface. The wave detector $12c_l$ detects and outputs a signal corresponding to the oscillation amplitude picked up in the detection coil of the oscillator $12c_k$. The integrator $12c_m$ integrates the signal outputted from the wave detector $12c_l$ and outputs the result to the controlling portion 18 (see Figure 3) through the amplifier $12c_n$.

When a detected object, i.e., of metal material, enters the magnetic field associated with the high frequency signal produced by the detection coil, electromagnetic induction causes an eddy current in the detected object. The eddy current is generated against the variation of magnetic flux produced at the detection coil, and the amplitude of oscillation of the internal oscillation circuit of the oscillator $12c_k$ is either reduced or becomes zero. In this way, proximity switches 12c detect the existence of the nearby metal elements by detecting such interaction.

Accordingly, here, it is preferable that metal lines or strips detectable by the proximity switches 12c are embedded in the surface to be cleaned, i.e. in the floor.

For example, as shown in Figures 6A through 6D, metal lines 61, 63, 65, 67 are formed on a plate 60 in a predetermined pattern. The metal lines 61, 63, 65, 67 are arranged such that the line width or spacing therebetween corresponds to the detecting area of the proximity switches 12c.

The metal lines 61, 63, 65, 67 can be formed in any of the exemplary patterns illustrated in Figures 6A through 6D, the lines being arranged under the plate 60, which may be referred to as a guiding plate or floor plate, so that they are not exposed or visible. It is further preferable that the guiding plate 60 is formed of a flexible insulating material.

The thickness of the guiding plate 60 is determined according to the sensing range of the proximity switches 12c of the robot cleaner 10. The thickness of the guiding plate 60 is preferably less than 5cm.

Figure 6A shows a matrix-type arrangement of metal lines 61, embedded in the guiding plate 60. In this case, when the proximity switches 12c move over the metal lines 61, all the proximity switches 12c1 - 12c5 output detection signals. Accordingly, the intersection is easily detected, and thus, the position of the robot cleaner 10 can be recognised accurately.

The front camera 13, mentioned previously, is arranged on the body 10a of the robot cleaner 10 and is arranged to photograph objects in front of the cleaner, and to output the photographed images to the controlling portion 18.

The driving portion 15 includes a pair of first wheels 15a, 15b mounted on lateral sides of the front part of the body 10a, a pair of rear wheels 15c, 15d mounted on the lateral sides of the rear part of the body, a pair of motors 15e, 15f for rotatably driving the rear wheels 15c, 15d, and a timing belt 15g equipped to transmit a driving motion from the rear wheels 15c, 15d to the forward wheels 15a, 15b. The driving portion 15 drives the motors 15e, 15f according to a control signal received from the controlling portion 18. Each of the motors 15e, 15f (which can rotate independently from each other) can rotate bi-directionally. In order to change the course or direction of the robot cleaner 10, the driving portion 15 drives the motors 15e, 15f at different rates, this resulting in a turning motion.

The transceiving portion 17 sends data to be transmitted to an antenna 17a, and transfers a received signal from the antenna 17a to the controlling portion 18.

The battery 19 is mounted on the body 10a in such a way that it can be charged via a charging terminal (not shown). The charging terminal is formed on an outer surface of the body 10a, and is arranged as such that it can be removably connected with an external charging device 30 (see Figure 3).

A battery charge level detecting portion 20 detects the charge level of the battery 19, and generates a signal (a charge request) when it is determined that the detected charge level is at a predetermined lower level.

The controlling portion 18 processes signals received through the transceiving portion 17, and controls other portions of the robot cleaner 10 accordingly. A key input device (not shown) having a plurality of buttons for enabling the selection of one or more functions of the robot cleaner 10 can be provided on the body 10a. Alternatively, a remote controller 40 can be provided, the controlling portion 18 processing the signals inputted from the key input device or from the remote controller 40.

The controlling portion 18 preferably controls the various portions of the robot cleaner 10 so that the robot cleaner maintains connection with the external charging device 30 during non-operation. By maintaining connection with the external charging device 30 during non-operation, the charge level of the battery 19 can be maintained within an adequate range of charge.

When separated from the external charging device 30 to perform an assigned operation, e.g. a cleaning operation, the controlling portion 18 returns the robot cleaner 10 to the external charging device 30 using course information obtained using the proximity switches 12c during the travelling of the robot cleaner. The controlling portion 18 may also use image information captured by the front camera 13 as supplementary information for performing a return operation or an assigned operation.

Here, 'assigned operation' includes operations such as a cleaning operation or a monitoring operation using the front camera 13.

When such an assigned operation is complete, or when a signal relating to a charge request is received from the battery charge level detecting portion 20 during an assigned operation, the controlling portion 18 of the robot cleaner 10 calculates a return course to the external charging device 30 by using course information calculated therein from the

time of separation from the external charging device 30, and controls the driving portion 15 to travel along the calculated return course whilst also preventing (or at least mitigating the effects of) deviation from the return course through the use of signals derived from the proximity switches 12c.

Preferably, the robot cleaner system is arranged to control the robot cleaner 10 externally, as well as controlling the processing and analysis of the image photographed by the front camera 13.

Accordingly, the robot cleaner 10 is arranged to transmit the image photographed by the front camera 13 wirelessly to an external device, e.g. the remote controller 40, and to operate in accordance with control signals received from outside, e.g. from the remote controller 40. The remote controller 40 wirelessly controls the robot cleaner 10 to perform a series of operations, such as cleaning operation, a returning operation, or the like.

The remote controller 40 includes a wireless relay unit 41 and a central control unit 50. The wireless relay unit 41 processes signals received from the robot cleaner 10 and transmits the processed signal to the central control unit 50 through a wire. The wireless relay unit 41 wirelessly sends signals received from the central control unit 50 to the robot cleaner 41 through the antenna 42.

The central control unit 50 can be a general computer, an example of which is represented in Figure 5. As shown in Figure 5, the central control unit 50 includes a central processing unit (CPU) 51, a read-only memory (ROM) 52, a random-access memory (RAM) 53, a display unit 54, an input unit 55, a memory unit 56, and a communicating unit 57.

The memory unit 56 has a robot cleaner driver 56a installed therein for controlling the robot cleaner 10 and for processing a signal transmitted from the robot cleaner 10.

Once executed, the robot cleaner driver 56a provides, through the display unit 54, a menu for setting controls relating to the operation of the robot cleaner 10, and then processes a series of jobs that allow the menu selection to be carried out by the robot cleaner 10. The menu includes categories relating to the cleaning operation and the monitoring operation, and sub-categories of menus such as a list of work area selections, operational methods, and the like.

Preferably, the robot cleaner driver 56a is provided with a geographical information recognition mode menu, and when this mode is selected, the robot cleaner 10 becomes separated from the external charging device 30, travels along the underlying surface to be cleaned, and generates and stores geographical information about the pattern of the underlying metal lines using the signals transmitted from the proximity switches 12c. The generation and storing of the geographical information can also be carried out in the robot cleaner 10.

The robot cleaner driver 56a controls the robot cleaner 10 to carry out an assigned job when it is a predetermined operation time, or when an operation command signal inputted through the input device 55 by a user is received.

The controlling portion 18 of the robot cleaner 10 controls the driving portion 15 and/or dust collecting portion 11 in accordance with the control information received from the robot cleaner driver 56a through the wireless relay unit 41. The controlling portion 18 also transmits images photographed by the camera 13, to the central control unit 50, through the wireless relay unit 41.

During the operation control, when a battery charging request signal is received from the robot cleaner 10, or an operation complete signal is received through the wireless relay unit 41, the robot cleaner driver 56a calculates the required return course to the charging device 30 using the geographical information derived from passing over the metal lines, as stored in the memory unit 56. The robot cleaner 10 is controlled to return to the external charging device 30 by following the calculated return course.

The process of controlling the robot cleaner 10 will now be described in greater detail with reference to Figures 7 and 8.

First, a pattern map of metal lines is generated and stored (step S100). The generation of the pattern map is performed when the user sets up the robot cleaner 10 for use, or when the user selects the geographical information recognition mode as part of the process for updating geographical information. Furthermore, the pattern map can also be generated every time the robot cleaner 10 is separated from the charging device 30.

Next, it is determined whether an operation request signal has been received (step S110). If an operation request signal is received, a travelling path for the assigned job is calculated using the geographical information relating to the metal lines as stored (step S120).

Next, the robot cleaner 10 travels along the calculated travelling path (step S130). The travelling path is determined such that the proximity switch 12c3 located in the middle of the set of proximity switches is above the metal line 65. The robot cleaner 10 travelling along the normal travelling path is shown in Figure 7 by the imaginary circle 'A'.

The next step, determines whether a metal line detection signal is inputted from only one of the outermost proximity switches 12c1, 12c5 (step S140). If the answer is 'yes', i.e., if the robot cleaner 10 has deviated from the normal travelling path to a position as indicated in Figure 7 by the imaginary circles 'B' and 'C', it is assumed that the robot cleaner 10 has reached a limit of its travelling course. Accordingly, the robot cleaner 10 is temporarily stopped, and course adjustment co-ordinates are calculated for the robot cleaner 10 to return to the normal travelling course.

More specifically, if the robot cleaner 10 is at position indicated by the circle 'B', the halted robot cleaner 10 is turned leftwards by 90°, advanced forwards by a distance corresponding to the distance between the proximity switch 12c3 in the middle and one outermost proximity switch 12c1, and then turned rightwards by 90° in the normal

advancing direction (indicated by the arrow). Accordingly, the proximity switch 12c3 in the middle is positioned to face the metal line. The course adjustment co-ordinates for effecting the change of direction, and for determining the distance of forwards movement of the robot cleaner 10, are calculated in step S150.

If the robot cleaner 10 is at the position indicated by the circle 'C', the halted robot cleaner 10 is turned rightwards by 90°, advanced forwards by a distance corresponding to the distance between the proximity switch 12c3 in the middle and the other outermost proximity switch 12c5, and then turned leftwards by 90°. Accordingly, the proximity switch 12c3 in the middle faces the metal line 61, and the course adjustment co-ordinates for effecting the change of direction, and for determining the distance of forwards movement, are calculated in step S150.

Next, in accordance with the calculated course adjustment co-ordinates, the driving portion 15 of the robot cleaner 10 is controlled to drive the robot cleaner 10 to return to the normal travelling course and then to the next target area.

Meanwhile, in the case where the robot cleaner 10 is at a position indicated by the circles 'D' and 'E' (as represented in Figure 7), i.e., where only the proximity switches 12c2, 12c4 between the outermost proximity switches 12c1, 12c5, and the proximity switch 12c3 in the middle, receive the metal line detection signal, the course is adjusted by varying the rotational velocity of the left and right wheels.

After the above travelling processes have completed, the operation is designated as complete (step S170), and accordingly, the operation is terminated.

As described above, a robot cleaner 10, a robot cleaning system, and a method for controlling the robot cleaner, allow recognition of the location of the robot cleaner 10, and of the travelling course of the robot cleaner 10, within a work area. This is performed in an easier way, and as a result, the performance of the robot cleaner 10 is improved, while the burden of having to process complex algorithms is reduced.

Claims

1. A robot cleaner for performing a cleaning operation while wirelessly communicating with an external device, comprising:

a driving portion that drives a plurality of wheels mounted on a body of the robot cleaner;

a dust collecting portion mounted on the body and arranged to collect dust from a floor surface within a work area;

a plurality of proximity switches arranged on a lower surface of the body facing the floor surface, the switches being spaced apart from each other by a predetermined distance and arranged to detect the existence of a metal member in the region of the floor surface; and

a controlling portion arranged to calculate a measure of the travelling distance and travelling course of the cleaner using a signal outputted from the proximity switches and to control the driving portion to perform an assigned operation using the calculated course.

2. A cleaner according to claim 1, wherein the proximity switches comprise:

an oscillator that generates an oscillating signal through a wave detection coil of the cleaner;

a wave detector that detects the amplitude of the oscillating signal from the wave detection coil; and

an integrator that integrates the signal outputted from the wave detector.

3. A robot cleaner according to claim 1 or claim 2, wherein the proximity switches are disposed in a row along an axis extending between two laterally opposed wheels of the cleaner.

4. A robot cleaner according to claim 3, wherein an odd number of proximity switches are provided and arranged such that one proximity switch is located centrally between the wheels and the remainder of the switches are disposed, in equal number, either side of the central proximity switch in a symmetrical manner.

5. A robot cleaner according to claim 4, wherein five proximity switches are provided.

6. A robot cleaner system, comprising:

a robot cleaner that performs a cleaning operation while communicating wirelessly with an external device, the robot cleaner having a plurality of proximity switches arranged in a row on a lower portion of a body; and

a guiding plate disposed over a work area, the guiding plate having metal lines arranged in a predetermined pattern, the metal lines being detectable by the proximity switches.

7. A robot cleaner system according to claim 6, wherein the metal lines are formed on a lower surface of the guiding plate.

8. A robot cleaner system according to claim 6 or claim 7, wherein the proximity switches are disposed in a row along an axis extending between two laterally opposed wheels of the robot cleaner.

9. A robot cleaner system according to claim 8, wherein an odd number of proximity switches are provided and arranged on the axis such that one proximity switch is located centrally between the wheels and the remainder of the proximity switches are disposed, in equal number, either side of the central proximity switch in a symmetrical pattern.

10. A robot cleaner system according to claim 9, wherein five proximity switches are provided.

11. A robot cleaner system according to claim 6, wherein the metal lines are formed such that a line width therebetween corresponds to a detectable area for each proximity switch.

12. A method of controlling a robot cleaner, the robot cleaner being arranged to recognise a travelling location using a detection signal from a plurality of proximity switches arranged on a lower surface of a body of the cleaner and being spaced apart by a predetermined distance from one another, and being configured to detect metal lines formed in a predetermined pattern on a floor surface of a work area, the method comprising the steps of:

generating and storing a map representing the pattern of metal lines while moving the robot cleaner within the work area;

in response to receiving an operation request signal, determining the location of the robot cleaner by comparing the pattern map with a detection signal generated by the proximity switches;

calculating a travelling path from the determined location to a targeting location; and

moving the robot cleaner along the calculated travelling path.

13. A method according to claim 12, wherein at least three proximity switches are provided and arranged in a row along an axis extending between two laterally opposed wheels of the robot cleaner,

the method further comprising the steps of:

when a detection signal is received from one of the outermost proximity switches during the moving process, temporarily stopping the moving process and calculating course adjustment co-ordinates including the required change of direction and forwards moving direction so that the central proximity switch is located over the metal line;

moving the robot cleaner in accordance with the course adjustment co-ordinates; and

when the metal line is detected by the central proximity switch, continuing the operation requested in the operation request signal.

14. A robot cleaner for performing a cleaning operation on an underlying cleaning surface while includes one or more metallic members arranged in a predetermined pattern, the robot cleaner comprising:

a body having a plurality of proximity sensors arranged on a lower surface thereof, each proximity sensor being arranged to output a detection signal in response to being within a predetermined range of a metallic member of the cleaning surface; and

control means arranged to receive a detection signal from one or more of the proximity sensors thereby to determine the position of the robot cleaner on the underlying cleaning surface.

15. A robot cleaner according to claim 14, wherein the control means is further arranged to calculate a driving path for moving the robot cleaner, from its determined position, to a target position on the underlying cleaning surface.

16. A robot cleaner according to claim 14 or claim 15, wherein each proximity sensor comprises means for generating a magnetic field around the sensor, and means for detecting a variation of magnetic field caused by a metallic member being within the predetermined range of the sensor.

17. A robot cleaner system, comprising:

a robot cleaner;

a surface comprising one or more metallic members arranged in a predetermined pattern thereover,

wherein the robot cleaner is arranged to perform a cleaning operation over the surface and comprises (i) a body having a plurality of proximity sensors arranged on a lower surface thereof, each proximity sensor being arranged to output a detection signal in response to being within a predetermined range of the or one metallic member of the surface, and (ii) control means arranged to receive a detection signal from one or more of the proximity sensors thereby to determine the position of the robot cleaner on the underlying cleaning surface.

18. A method of controlling a robot cleaner according to claim 14, the method comprising:

driving the robot cleaner over an underlying cleaning surface including one or more metallic members arranged in a predetermined pattern;

operating the robot cleaner such that it generates and stores a map representing the pattern of sensed metallic member(s);

in response to receiving a command signal from an external device, determining the current position of the robot cleaner using one or more of the sensors;

calculating a path from the current position to a target position indicated in the command signal; and

moving the robot cleaner along the calculated path.

19. A robot cleaner constructed and arranged substantially as herein shown and described with reference to the accompanying drawings.

20. A robot cleaner system constructed and arranged substantially as herein shown and described with reference to the accompanying drawings.

21. A method of controlling a robot cleaner, substantially as herein described with reference to the accompanying drawings.

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Claims searched: 1-18 **Date of search:** 24 January 2003

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
X	14, 15, 17	US 5189612	(PROTEE GROUPMENT) See figures 1-8, items 2 and 3, and the description, especially in columns 3 and 4.
A, E		GB 2376536 A	(SAMSUNG KWANGJU ELECTRONICS) Whole document.
A		GB 2344900 A	(NOTETRY LTD.) Whole document.
A		US 3010129	(WHIRLPOOL CORPORATION) Whole document, especially the description in column 3 at lines 49-64.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[V]:

G3N; G3R; B7H

Worldwide search of patent documents classified in the following areas of the IPC[7]:

A47L; B25J; G01S; G05D; H03K.

The following online and other databases have been used in the preparation of this search report :

WPI, EPODOC, JAPIO.